

Differentiating *Paralithodes* larvae using telson spines: A tail of two species*

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Identification of larvae belonging to closely related species of decapod Crustacea is frequently dependent upon few (often single) morphological characters. Since larvae used in descriptions are often the offspring from a single captive, very little is known about how intraspecific variability may affect the ability to differentiate species. Two congeneric decapods whose zoeae are separated on the basis of a single morphological character are the red king crab (RKC) *Paralithodes camtschaticus*, and blue king crab (BKC) *P. platypus*. Larvae of these

commercially-important species are distinguished from each other by the number of spines or processes on the telson, RKC having 7 pairs of spines and BKC 8 pairs, excluding a minute seta (Sato 1958, Haynes 1984). However, when viewed together there are other apparent differences: BKC zoeae have proportionately shorter rostrums and carapace spines, larger bodies at each stage, and larger eyes.

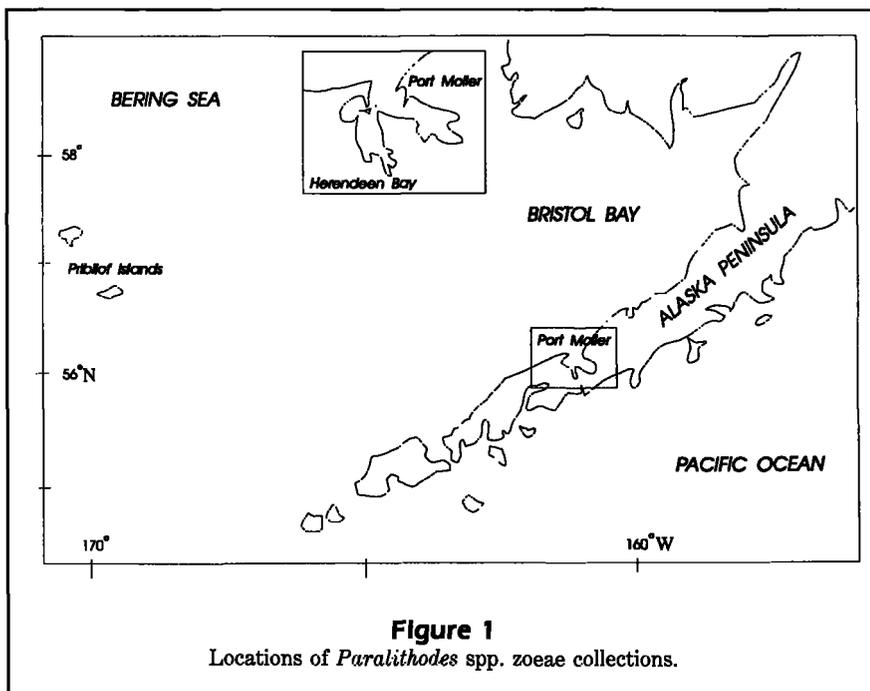
During the course of extensive plankton sampling for king crab larvae in Herendeen Bay within Port Moller, Alaska, considerable variability in telson morphology was noted. A large proportion of zoeae resembling BKC were captured

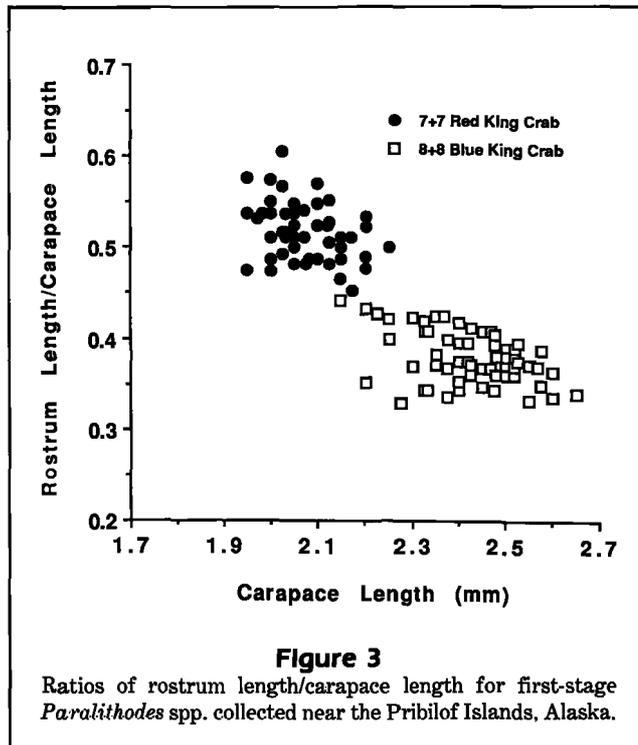
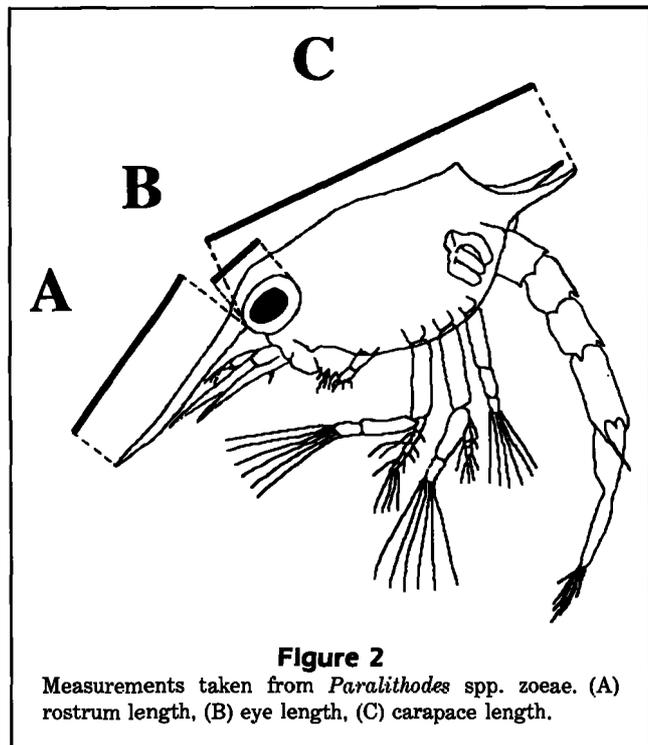
having an asymmetrical pattern of 8+7 telson spines, while others, also appearing to be BKC in other respects, had only 7 pairs; such interspecific character overlap had not been noted with these two species near the Pribilof Islands, Alaska (Armstrong et al. 1985). To confirm the identity of these zoeae and provide additional characters to separate the two species, several measurements were taken on specimens from Herendeen Bay and the Pribilof Islands to establish a stronger, more quantitative basis to distinguish these larvae.

Materials and methods

Paralithodes zoeae were collected near the Pribilof Islands, Alaska, in May 1983 and April 1984, and from Herendeen Bay, Alaska (Fig. 1) in May and June of 1990, using either a 505 μ m mesh Tucker trawl or a 60 cm bongo net with a mesh of 333 or 505 μ m. Samples were preserved in 5% buffered formalin in seawater and later sorted for target species, which were transferred to a solution of 70% ethanol and 5% glycerol. The number of telson spines (excluding a minute seta) was recorded for each specimen, and three measurements were taken: tip of rostrum to the anteriormost edge of the eye ("rostrum length"), anterior edge of eye to the tip of the posteriolateral carapace spines ("carapace length"), and the longest dimension of the eye ("eye length," Fig. 2). Damaged or distorted specimens were not used for measurements, but spine counts were recorded. A total of 608 larvae were measured; 371 from Herendeen Bay and the remainder from around the Pribilof Islands. The ratios of rostrum length to carapace length were plotted against carapace length for "normal" (i.e., 7+7 telson spine RKC and 8+8 BKC)

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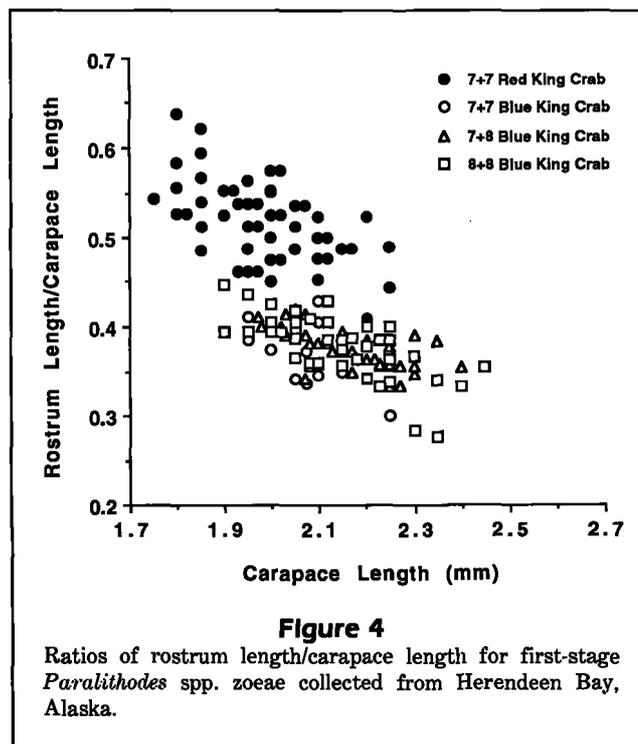


zoeae of both species in the two areas. Those with an anomalous number of spines (8+7 and "BKC" with 7+7) were then similarly plotted for comparison.

Unless otherwise indicated, data are presented as mean ± 1 standard deviation. ANOVAs were used to test for significant differences ($\alpha \leq 0.05$) between the means of different groups, and the means compared using Tukey's T method. A two-way ANOVA was used to examine intraspecific variation in zoeae I between the two areas.

Results

Plotted ratios of rostrum length/carapace length for Pribilof Island specimens fell into two distinct clouds representing those thought to be RKC (longer rostrum) and BKC (Fig. 3). These were not so clearly separated in the samples from Herendeen Bay; nevertheless, all those with an asymmetric telson spine pattern or a short rostrum, large body, and spine count of 7+7 fell within the cloud of 8+8 BKC larvae (Fig. 4). These larvae were designated as BKC and divided into groups based on number of telson spines. The ratios for all of these groups were significantly different ($p < 0.05$) at each zoeal stage from the means for RKC zoeae; Figure 5 shows combined results for both species at the two locations. Both the carapace and eyes of BKC larvae were significantly longer than those of RKC at all



stages, but these differed considerably between the two areas. Two-way ANOVA revealed no significant difference in rostrum/carapace length ratio for zoeae I BKC from the two areas, but significantly smaller

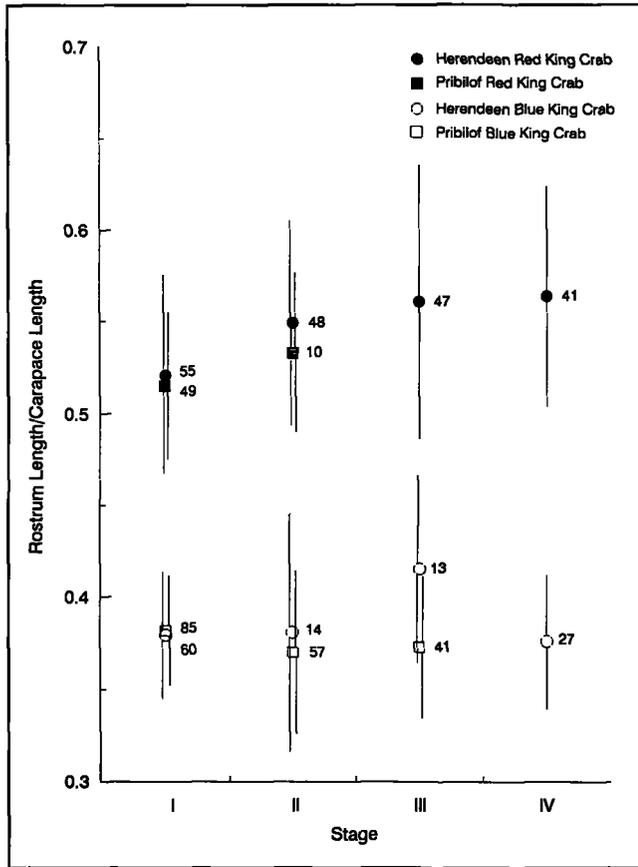


Figure 5
Paralithodes spp. rostrum length/carapace length by stage. Values are mean ratios (± 1 SD); numbers are the number of zoeae measured for each value.

eyes for Herendeen Bay BKC, suggesting that eye length is not reliable for distinguishing the two species. No intraspecific differences between areas were detected for either rostrum/carapace length or eye length for RKC.

The mean eye length of RKC larvae was significantly less ($p < 0.05$) at each stage than the means of all groupings of BKC. In addition, the mean of the 7+7 zoeae-I BKC was significantly less than those with 8+8 (Fig. 6). BKC larvae from Herendeen Bay showed great variation in number of telson spines. Only 45.9% of all BKC larvae had a spine count of 8+8, the majority having some other combination of 7, 8, or 9 spines on each side of the telson. In contrast, the majority of BKC zoeae from the Pribilof Islands (84%) had a spine count of 8+8 (Fig. 7). RKC larvae showed little variation in telson spines, with only 0.9% of the zoeae from Herendeen Bay and 3.2% from the Pribilof Islands deviating from the count of 7+7.

Discussion

BKC zoeae are generally distinguished from RKC zoeae by the presence of an additional pair of inner spines on the telson (Fig. 8A,B), and for king crab zoeae collected near the Pribilof Islands this was a reliable character for separating the two species. Only 3.2% of the RKC zoeae collected from this area deviated from the 7+7 pattern. Even though 16% of the BKC zoeae differed from 8+8, this difference was almost invariably in the form of an extra 1 or 2 inner spines, making confusion with RKC unlikely. BKC zoeae were visibly much larger as confirmed by their greater carapace length, and had shorter rostrums and larger eyes.

A substantially different pattern was apparent in samples from Herendeen Bay, where 42% of zoeae-I BKC were missing one spine from the telson (Fig. 8C) and an additional 18% missing two spines (Fig. 8D). Because the missing spines are the innermost of the two pairs, those remaining tend to be considerably longer than the single pair in RKC; yet as Figure 8D

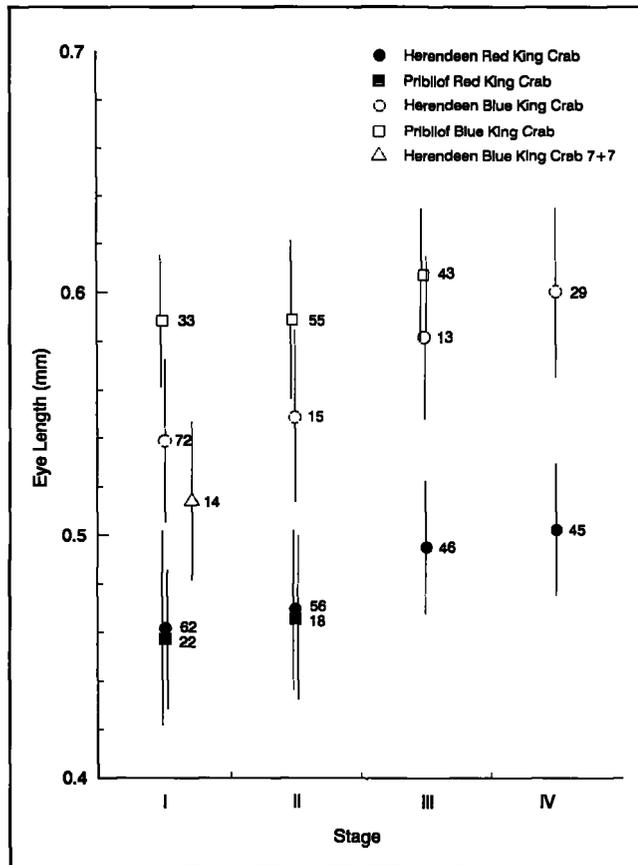


Figure 6
Mean eye length (± 1 SD), and number of *Paralithodes* spp. zoeae measured.

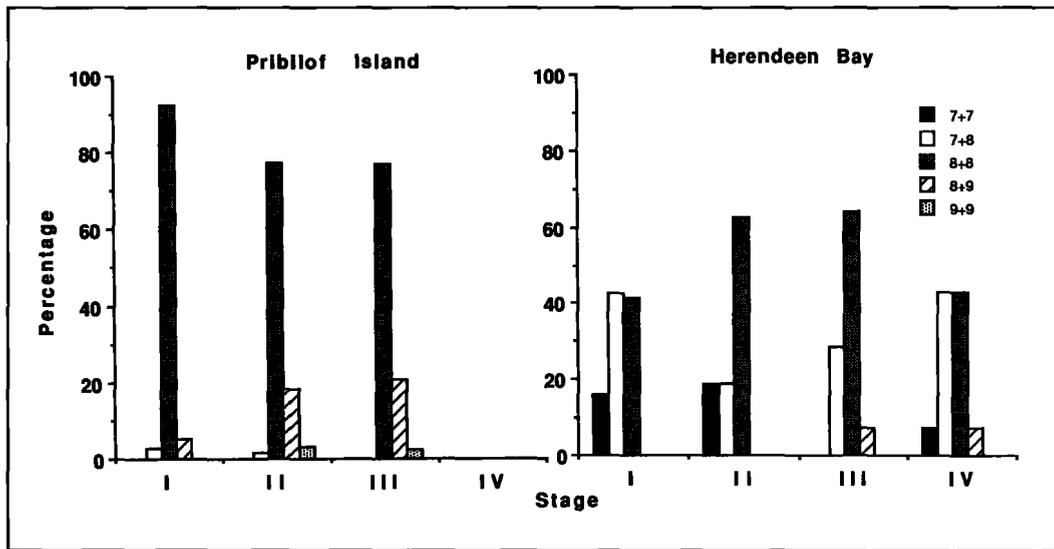


Figure 7
Number of telson spines of *Paralithodes platypus* zoeae collected from the Pribilof Islands and Herendeen Bay.

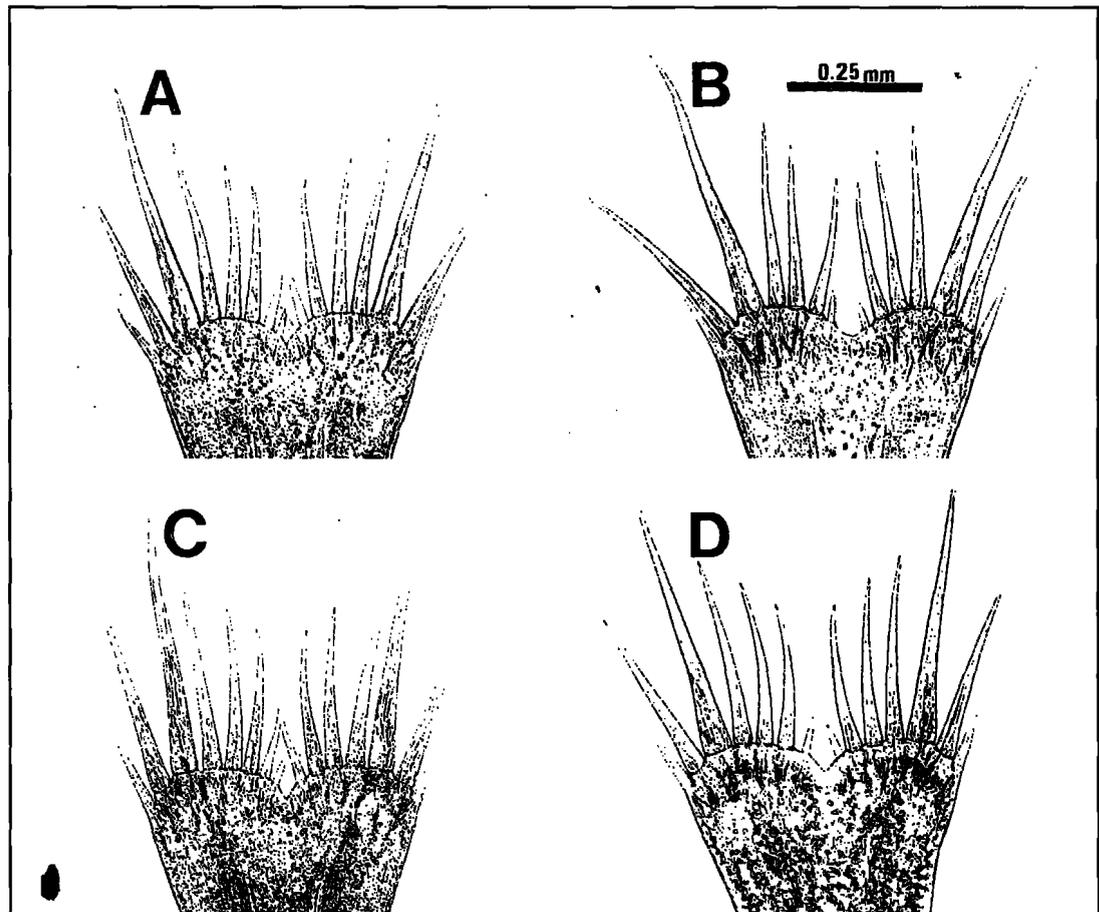
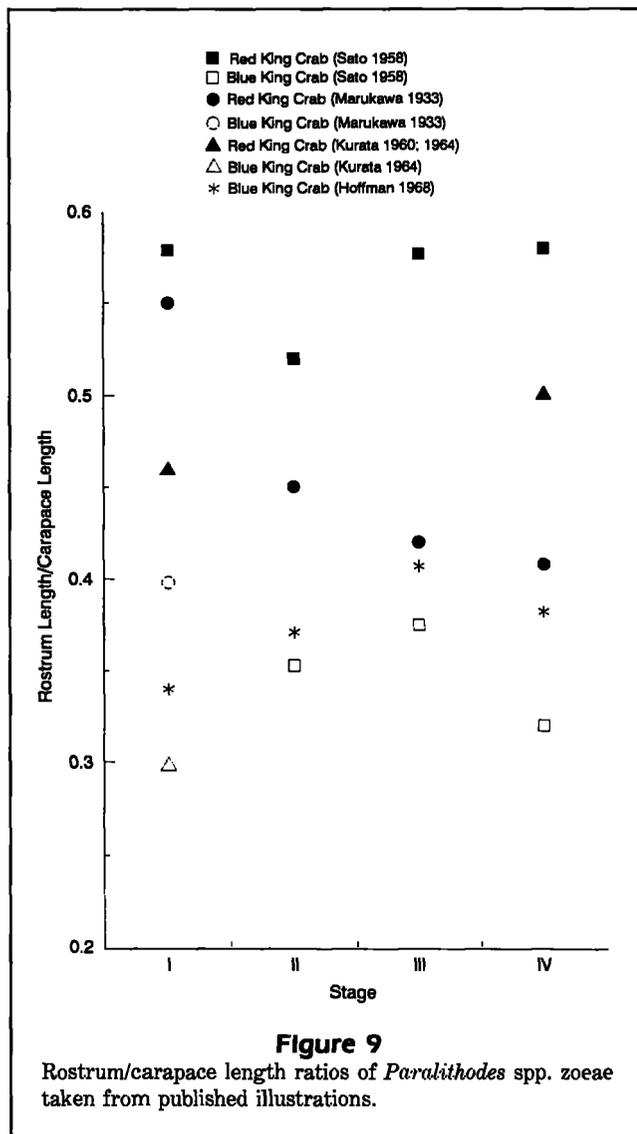


Figure 8
Telson spines of *Paralithodes* spp. zoeae. (A) *P. platypus*, "typical" 8+8 pattern; (B) *P. camtschaticus* 7+7; (C) *P. platypus* 8+7; (D) *P. platypus* 7+7 (identification based on eye and ratio of rostrum length/carapace length).



shows, this difference is sometimes negligible. However, BKC were readily distinguished from RKC by their proportionately shorter rostrums, larger eyes, and larger bodies, but the differences were not as great as those seen in the Pribilof Islands. Zoeae in both locations appeared to gain additional telson spines with larval stage, a pattern noted previously for other lithodid larvae by Kurata (1964). While rostrum length alone was not reliable for separating the two species (due to intraspecific variation between the two areas), the proportion of rostrum length to carapace length remained constant and appears to be a useful method of differentiating the two. Whether this is reliable in other areas is not known, but it is consistent with illustrations in published descriptions of the two species (Fig. 9).

Of particular interest is the intraspecific variability exhibited both between the two areas and within the

population in Herendeen Bay. While there were no significant differences between populations of RKC, all linear measurements of BKC zoeae from Herendeen Bay averaged 10–12% smaller than those of conspecifics from the Pribilof Islands. The cause of this variation is not known, but environmental factors such as temperature can affect both the number of decapod larval stages (Knowlton 1974) and their morphology (Shirley et al. 1987). Temperatures differed considerably between the two areas at the time of larval collection. At the Pribilof Islands in May 1983 the water was 2–4°C, and –1–1.5°C in April 1984 (Armstrong et al. 1985). In Herendeen Bay larvae stayed above a 40 m thermocline in water 2.5–8.5°C, and developmental times were exceptionally fast (Wainwright et al. 1991).

BKC have an extremely disjunct distribution (Somerton 1985), and it is also possible that size differences could be related to their reproductive isolation. But although local environmental features or isolation may explain differences between the two populations, they are unlikely to account for the variation seen within the relatively small scale of Herendeen Bay. The eyes of BKC zoeae having a 7+7 spine pattern were intermediate in length between the 8+8 or 8+7 BKC larvae and RKC from Herendeen Bay (Fig. 7). The cause of such differences cannot be known without appropriate experiments and genetic studies, but the recent report of an adult RKC-BKC hybrid from the Sea of Okhotsk (Nizyayev 1991) raises the possibility that some interbreeding may occur within the confines of Herendeen Bay.

Because all larvae were collected from the plankton rather than hatched in captivity, we cannot state unequivocally that these differences in spine count are due to intraspecific variation of BKC rather than a mixture of other lithodid species. However, megalopae, juveniles, and adults of RKC and BKC were collected within Herendeen Bay during the course of this study; despite extensive trawling, pot fishing, dredging, and intertidal surveys, the only other lithodid found was *Hapalogaster grebnitzkii*. Larvae matching the description for *H. grebnitzkii* were also the only other lithodid zoeae occurring in the plankton samples. The large size, shape, and position of the posterolateral carapace spines, coupled with a lack of carapace sculpturing, readily distinguish RKC and BKC zoeae from other described species of Bering Sea lithodids. We believe it is extremely unlikely that the variation is due to a fourth, undescribed species.

No single character for reliably separating BKC and RKC zoeae was observed, but since the number of telson spines is useful for differentiating the two species in some areas (e.g., Pribilof Islands), we suggest using this count along with the rostrum/carapace

length ratio until the extent of character overlap is known. A ratio of >0.45 (RKC) or <0.45 (BKC) usually distinguished the species in our samples from both areas. Eye measurements, like spine counts, vary with area but can be useful when the rostrum or carapace is damaged or distorted. In our samples the overlap in telson spine counts was greatest in zoeae I, but fortunately this was the stage when the two species could be most reliably distinguished by the proportion of rostrum to carapace length.

Acknowledgments

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